Car Bonnet Optimisation for Adult head injury safety by FEA analysis

Sagar Patel, Prof. M.H.Patil

[1,2]*Mechanical Engineering Dept., D. N. Patel college of Engineering, Shahada, India*

Abstract— Exploration on adult people walker protection as of now is concentrating mostly on traveler vehicles and business vehicles. Be that as it may, impacts with heavy products vehicles and transports are likewise significant, particularly in urban regions and in developing nations. This examination is an endeavor to show the circulation of injury designs concentrated on the head injury component. The head was discovered the most harmed area. In 2018, there were 6,283 walkers slaughtered in car accidents, up from 5,977 the prior year. NHTSA's pedestrian security programs center around the practices of pedestrian and drivers to diminish wounds and fatalities on our country's streets. Besides functioning as associate degree engine compartment cowl, the bonnet of contemporary vehicles may also facilitate manage the impact energy of a pedestrian's head in an exceedingly vehicle-pedestrian impact. However, a bonnet's ability to soak up impact energy is also obstructed by the proximity of the bonnet to parts packaged within the engine compartment, i.e., by it's beneath bonnet clearance. For instance, for a given bonnet style, the bonnet's ability to soak up impact energy through deformation are often considerably reduced once the bonnet and cylinder block square measure in shut proximity. The aim of those tests was to match the final pedestrian friendliness of steel and metal, used as hood material. The tests were conducted on a automobile that's still on the market on the market with either a steel or metal hood, each having identical style. Knowing that the hood style wasn't developed to fulfill pedestrian safety needs, the results compare the appliance of each steel and metal to assess that hood material is favorable for pedestrian protection..

Keywords—Pedestrian safety, bonnet, hood, FEA analysis,

1. INTRODUCTION

Head and face injuries in car–pedestrian accidents account for 60 per cent of all pedestrian fatal injuries, whereas 17.3 per cent of head injuries were due to the bonnet [1]. The above values show the necessity to consider more carefully the role of the bonnet in pedestrian head safety. Redesigning the bonnet structure to improve pedestrian protection has recently received considerable attention by automobile manufacturers and industry institutes. However, there is a lack of research that considers methods of choosing the most effective thicknesses of bonnet skin and bonnet reinforcement with respect to pedestrian safety. With the great number of pedestrian deaths and injuries occurring from automobile accidents, an effort is being made worldwide to establish automobile safety regulations for pedestrian protection. The hood and bumper, with which pedestrians come in frequent contact, can be designed and manufactured to be pedestrian friendly, effectively decreasing injuries [4]. During the development of a safe hood and bumper structures, experiments and computer simulations are used to evaluate their performances Computer simulations contain many errors from inaccurate modeling and approximation of governing Equations. On the other hand, experiments are considered to be accurate even with the possibility of experimental errors and inaccuracies. In design, it would be the best if all the data could be obtained from experiments. However, an experiment is generally very costly. Therefore, limited experiments are performed in many application fields. When an experiment is extremely expensive, even the experiments with an orthogonal array are almost impossible to conduct in order to find a good design. In this case, some experiments can be replaced by computer simulations.

In 2018 7,991 pedestrians were killed in road traffic accidents in the EU-23, which is 20.4 % of all fatalities. In the last decade, pedestrian fatalities have reduced by 25.2%, while the total number of fatalities has reduced by nearly 30%. Road safety measures implemented in the last 10 years may have helped to reduce the number of pedestrian fatalities.

The variation in rates of death observed across regions and countries also corresponds with differences in the types of road users most affected. Vulnerable road users – pedestrians, cyclists and motorcyclists – represent more than half of all global deaths. Pedestrians and cyclists represent 26% of all deaths, while those using motorized two- and three-wheelers comprise another 28%. Car occupants make up 29% of all deaths and the remaining 17% are unidentified road users1. Africa has the highest proportion of pedestrian and cyclist mortalities with 44% of deaths. In South-East Asia and the Western Pacific, the majority of deaths are among riders of motorized two and three-wheelers, who represent 43% and 36% of all deaths respectively.

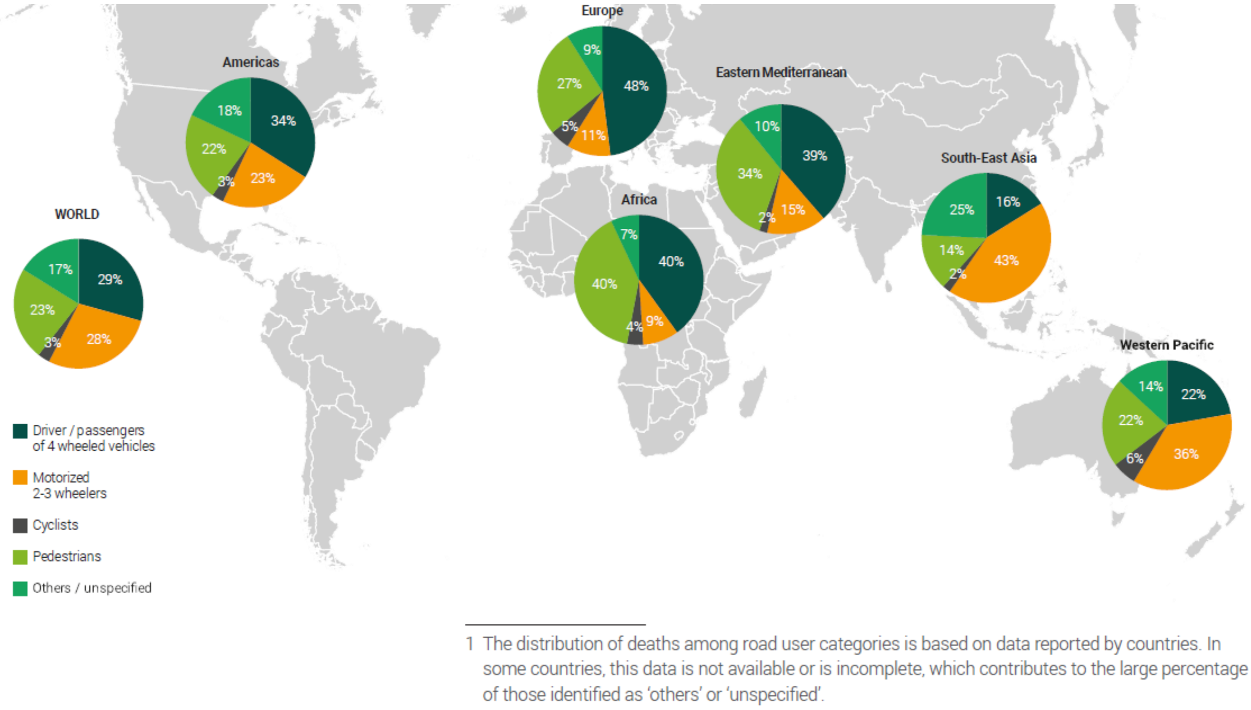

Fig. 1 Distribution of deaths by road user type, by WHO Region

Every day, almost 3,700 people are killed globally in road traffic crashes involving cars, buses, motorcycles, bicycles, trucks, or pedestrians. More than half of those killed are pedestrians, motorcyclists, and cyclists.

Globally, 54% of accident related deaths are pedestrians, cyclists and motor cyclists. This results in considerable economic losses not only to individuals, their families, but also to the nations as a whole. The losses are on account of cost of treatment as well as lost productivity for those killed or disabled by their injuries, loss of productivity of family members who need to take time off work or school to care for the injured etc.

2. METHODOLOGY

2.1 Pedestrian Protection Regulations and Experiments

Impact test for pedestrian protection is implemented as illustrated in Figure 2 [3]. The experiment uses the standards of the impact experiments for the second stage child head model and the first stage lower body model in the Directive 70/156/EEC (2003/102/EC) [2]. The child head model is impacted on the hood. The horizontal impact angle is 50° with the wrap around distance (WAD) between 1,000-1,500mm. Impact speed is 40km/h and the required HIC (Head Injury Criterion) is 1,000 or lower. HIC is calculated from Equation (1) [3].

$$HIC = \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \mathbf{a} \, dt \right]^{2.5} (t_2 - t_1) \quad \text{------ (1)}$$

Where "a" is the resultant acceleration measured in units of gravity "g"(1g = 9.81m/sec2), "t1"and "t2"are the two time instances(expressed in seconds) during the impact, defining an interval between the beginning and the end of the recording period for which the value of HIC is the maximum (t2 – t1≤15msec). [3]

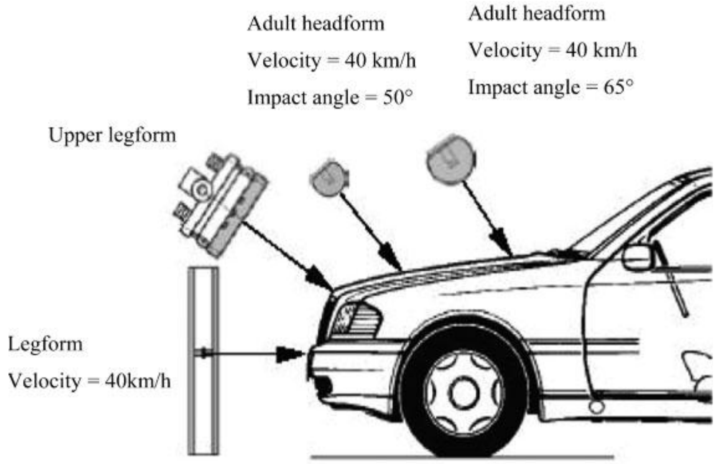

Fig. 2 Pedestrian protection concept proposed by the EEVC WG17 [3].

The adult headform impactor shall be made of aluminium, be of homogenous construction and be of spherical shape. The overall diameter is 165 ± 1 mm as shown in Figure 13. The mass shall be 4.5 ± 0.1 kg. The moment of inertia about an axis through the centre of gravity and perpendicular to the direction of impact shall be within the range of 0.010 to 0.013 kgm2. The centre of gravity of the headform impactor including instrumentation shall be located in the geometric centre of the sphere with a tolerance of ±5 mm.

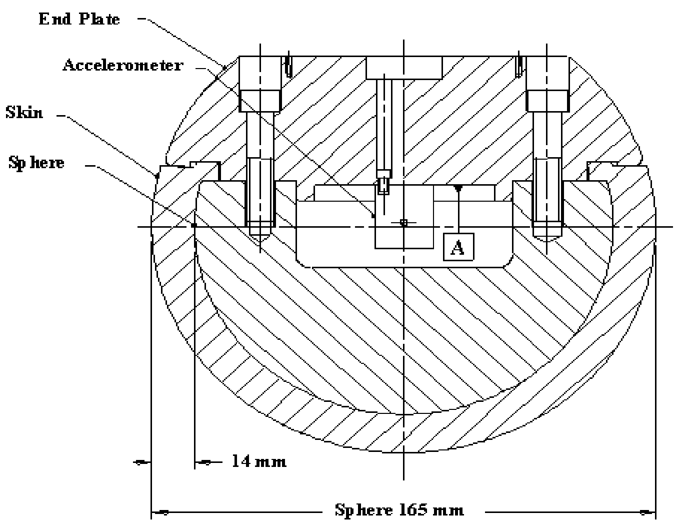

Fig 3 Adult head-form impactor

As per regulation the headform velocity at the time of impact shall be 9.7 ± 0.2 m/s. The direction of impact shall be in the longitudinal vertical plane of the vehicle to be tested at an angle of 65 ± 2° to the horizontal as shown in figure 4.

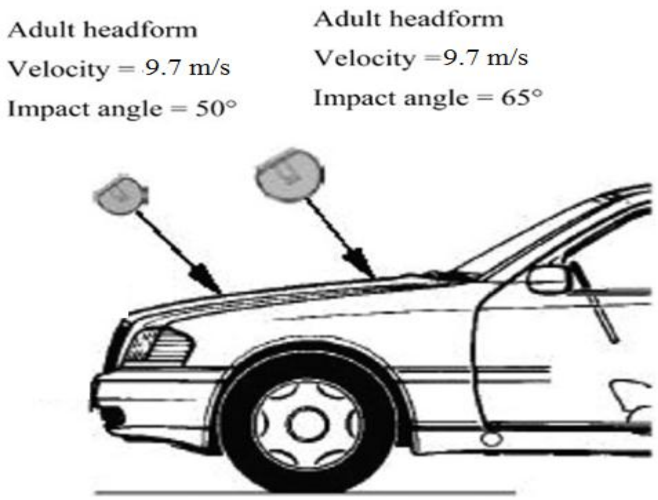

Fig. 4 Pedestrian protection concept proposed by the US regulation

In India there is no such regulation for vehicle manufacturing. The adult headform impactor is used to test the points lying on boundaries described by a WAD of 1500mm and the rear of the bonnet top, or a WAD of 2100mm for a long bonnet. Each section is divided into three parts, as illustrated in Figure 5.

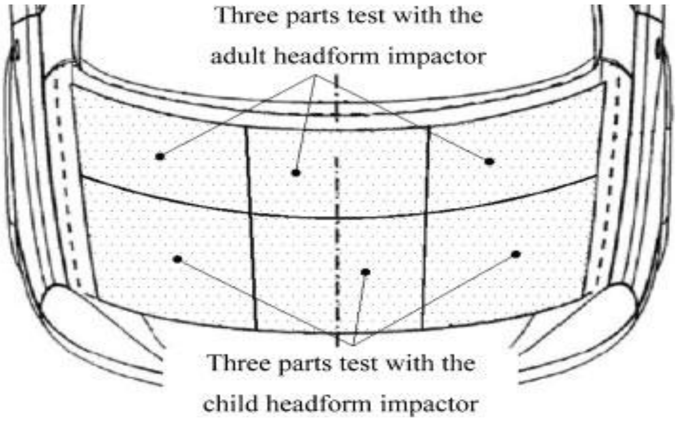

Fig. 5 Description of the impact area for pedestrian headform- impactor-to-bonnet-top tests

In each part, a minimum of three tests is carryout at spots with high injury risk. Test points should vary according to the types of structure, which vary throughout the assessment area.

2.2 Finite element model and simulation

In Finite element the model of vehicle and adult head-form is crated. This study analyses the effect of the bonnet skin and bonnet reinforcement thicknesses on pedestrian head injury by performing head-form impactor simulations of the US regulations using different thicknesses.

The Reduced Car Model is at the same level when the Full Vehicle is standing on the level floor. All translational and rotational degrees of freedoms are fixed (arrested) at the cutting location of BIW. Head is positioned as per Adult Head Impact Zone at 650 to horizontal. The Head is impacted with initial velocity of 9.7 m/s. Head accelerations are measured from the accelerometer fitted in Headform.

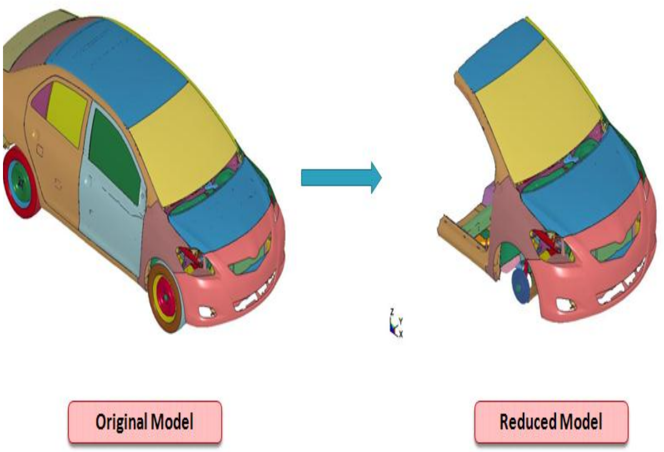

Fig. 6 FE original model and reduced model

Table 1 lists proposed HIC tolerance levels correlated with brain injury and skull fracture [7]. Based on this tolerance, the level of 1800 represents the maximum allowable HIC value, and an HIC value less than 650 represents the best pedestrian protection, which is the level of zero injury.

TABLE 1 Proposed HIC tolerance levels

HIC range	Brain injury	Skull fracture	Euro-NCAP
< 150	No concussion	No fracture	< 650, green
150–500	Mild concussion, less than 1 h	No fracture	< 650, green
500–900	Severe concussion, 1–24 h	Minor fracture	< 650, green 650–767, yellow 767–883, orange
900–1800	Severe concussion, 1–24 h	Major fracture	883–1000, brown > 1000, red
> 1800	Life threatening	Life threatening	> 1000, red

Bonnet-top simulations are performed using the adult headform impactors simulations of the headform-to-bonnet-top test are performed using the finite element models of the headform impactor mentioned above. The test point are selected are shown in figure 7. In the engine compartment, components that are close to the bonnet top include the oil cap and the battery. This study does not consider the effect of the engine compartment arrangement on the head injury criterion (HIC) value. Therefore, all parts in the engine compartment that are close to the bonnet are moved down to ensure that the bonnet does not impact any parts in the engine compartment during simulation.

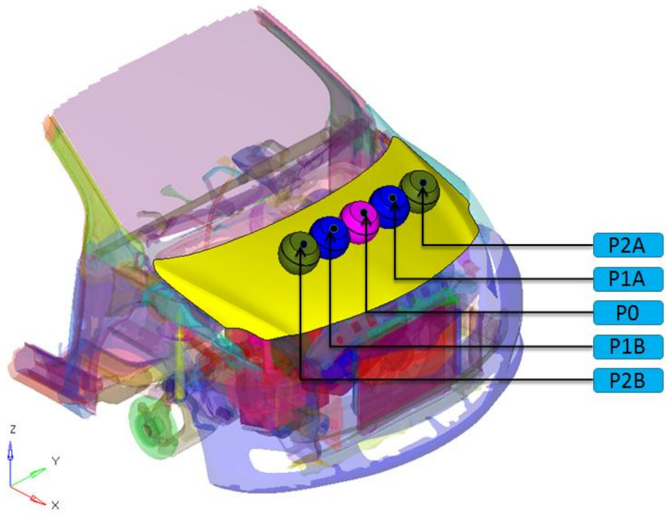

Fig. 7 The test point selected on Bonnet surface

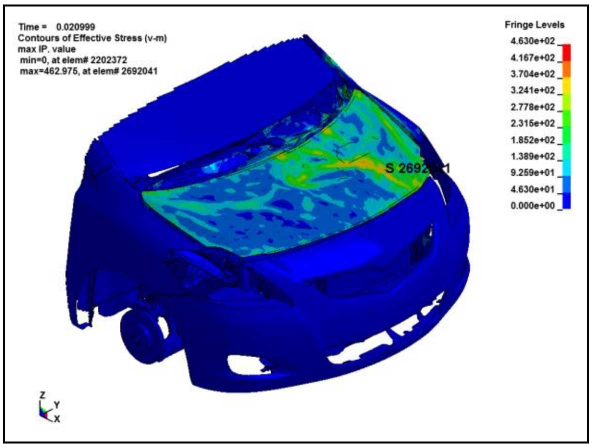

Fig 8 Overall Stress Plot

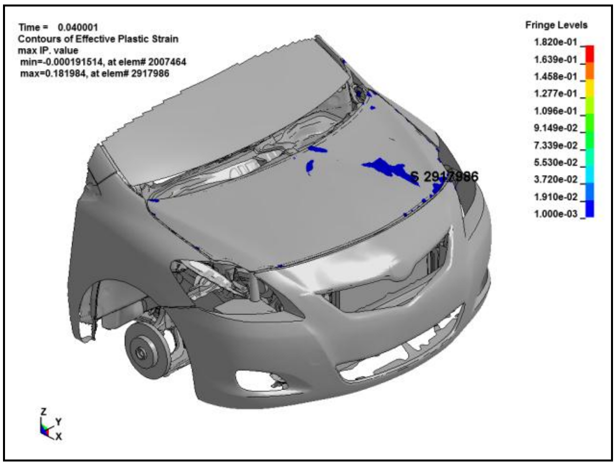

Fig 9 Overall Strain Plot

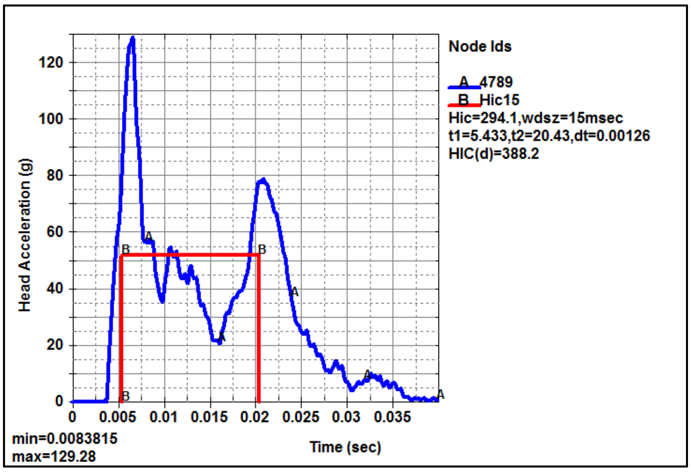

Fig 10 HIC value

The HIC value obtained from the FEA analysis is in the range of acceptable criteria. It seem a cost effective solution for the adult head and vehicle collision simulation.

3. CONCLUSION

In this way we can simulate the bonnet to head impact test. By using simulation technique the result is obtained which is approximating same to the real test results. By using simulation we can save the time cost of the test. This study shows that the interdependence of the HIC value, the bonnet reinforcement thickness, and the bonnet skin thickness is very complicated. This study analyses and proposes a method of identifying the most useful values for the bonnet reinforcement thickness and the bonnet skin thicknesses to defend pedestrians while maximizing the bonnet stiffness. The method presented in this study uses the regression technique to design constraints for the optimization problem. The proposed algorithm identifies numerous critical positions on the bonnet surface with respect to pedestrian safety. The algorithm used to optimize the thicknesses is solved by combining LS-DYNA to simulate and analyse the simulation results. Compared with the original bonnet, the optimal bonnet is more pedestrian friendly but somewhat less stiff than the original bonnet.

4. REFERENCES

[1] National Crime Records Bureau Ministry of Home Affairs Government of India East Block - 7, R.K. Puram New Delhi, "Accidental Deaths and Suicides in India 2010"

[2] Directive 2003/102/EC of the European Parliament And Of The Councilof 17 November 2003, Official Journal of the European Union, L 321/15, 6.12.2003

[3] Teng T-Land NgoV-L, "Optimization of bonnet thickness with respect to pedestrian safety", DOI: 10.1243/09544070JAUTO1477, CASE STUDY 1513, JAUTO1477, Proc. IMechE Vol. 224 Part D: J. Automobile Engineering, publication on 16 June 2010

[4] FHWA/NHTSA National Crash Analysis Center", The George Washington University, Ashburn, Virginia, USA, Applications, Finite element model archive, 2000–2009

[5] F. A. Berg, M. Egelhaaf, J. Bakker, H., Burkle, R. Herrmann, and J. Scheerer, "Pedestrian protection in Europe – the potential of car design and impact testing", Report for the United Nations, UN Economic Commission for Europe.

[6] "National Center for Statistics and Analysis", Motor vehicle traffic crash fatality counts and estimates of people injured for 2012: 2012 annual assessment. Report DOT HS 811 552, National Highway Traffic Safety Administration, Washington, DC, USA, February 2012.

[7] Y. H. Han, and Y. W. Lee, "Development of a vehicle structure with enhanced pedestrian safety", SAE paper 2003-01-1232, 2003

[8] C. K. Simms, "Developments in crash safety: a triumph of design in bioengineering", In Perspectives on design and bioengineering: essays in honour of C. G. Lyons (Eds C. K. Simms and P. J. Prendergast), 2008, pp. 39–55 (Trinity Centre for Bioengineering, Dublin).

[9] I.Kalliske, and F.Friesen, "Improvements to pedestrian protection as exemplified on a standardized car", 17th International Technical Conference on The enhanced safety of vehicles (ESV), Amsterdam, The Netherlands, 4–7 June 2001, paper 283, 10 pp. (National Highway Traffic Safety Administration, Washington, DC

[10] V. Philomin, R. Duraiswami, and L. Davis, "Pedestrian tracking from a moving vehicle", IEEE Intelligent Vehicles Symposium (IV 2000), Detroit, Michigan, USA, 3–5 October 2000, pp. 350–355 (IEEE, New York).